



Scientists study glaciers in McMurdo Dry Valleys in Antarctica

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The McMurdo Dry Valleys of Antarctica host the coldest and driest ecosystem on Earth. The sensitivity of these glaciers to climate change is not well understood. A research team, including Matthew Hoffman of LANL's Fluid Dynamics and Solid Mechanics group, has modeled the spatial variability in ice loss and assessed climate sensitivity of the glaciers. The researchers compared their models with 16 years of meteorological and glacial surface mass data collected in Taylor Valley. The [Journal of Glaciology](#) published their findings.

Significance of the work

This polar desert is acutely sensitive to the availability of water coming from glacial runoff. Snowfall is infrequent, and most snow sublimates with relatively little melt to the soils and streams. Glacier surfaces are typically below the melt threshold during the summer, and runoff is quite limited given the large expanse of ice present in the valleys. Most ice loss occurs due to ice melt and sublimation (direct evaporation without melting). Because there has been little research on the climate sensitivity of these glaciers and polar glaciers in general, the effect of climate change on the glaciers is not well understood.

The new findings showed that sublimation was the primary form of ice mass loss over much of the glaciers. The exception occurs near the termini of the glaciers, where melt below the ice surface in an ice weathering crust dominated. Microclimates in rough basins generated melt rates up to ten times higher than over smooth glacier surfaces. In contrast, the vertical terminal cliffs of the glaciers can have higher or lower melt rates than the horizontal surfaces due to differences in incoming solar radiation associated with cliff aspect. Glacial surface mass sensitivity to changes in temperature may be the smallest magnitude observed globally. The authors attribute this low sensitivity to the cold climate such that most of the energy received at the glacier surface warms the ice up to the melting point each spring or is lost to the atmosphere through sublimation. The simulations reveal that the sensitivity increases as the climate is increasingly warmed, and melting becomes more frequent. In summer the glaciers of Taylor Valley are on the verge of melting such that small changes in the energy balance have profound effects on ice mass loss. These factors interact, producing greater ice loss than any one factor alone.

The researchers also identified a high sensitivity to ice albedo (amount of sunlight reflected from the surface of the ice). Ice usually has a very high albedo. An albedo

decrease of 0.02 has similar effects to the ice mass to a 1 K increase in temperature. This albedo change may have been caused by wind transporting sediments from the valley floor to the surface of the glaciers. The albedo result indicates that modest increases in dust deposition could have a far larger effect on melting of these glaciers than the temperature change expected from future climate change for this region.

Achievements

The research team used a model they had developed previously that describes the surface energy-balance processes that are important for the glaciers of the McMurdo Dry Valleys. The model reproduces observations of surface lowering, ice temperature and ice density when penetration of solar radiation into the ice is included and when subsurface meltwater is allowed to drain away. The investigators applied the model across the ice loss zones of the glaciers of Taylor Valley to determine whether the previous results and processes explain valley-wide mass-balance observations over 15 summers. After validating the model across the valley, the team used it to investigate a change in ablation sensitivity that occurred midway through the period of study. They also assessed climate sensitivity of the glaciers, considering changes to air temperature, ice albedo and wind speed.

The research team

In addition to Hoffman, authors of the publication are Andrew G. Fountain of Portland State University and Glen E. Liston of Colorado State University.

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Captions for images below: *The smooth surface and cliff of a glacier is shown below in the photo. The graphic below is a map of modeled summer melt rates across the glaciers — (a) sublimation on smooth surfaces; (b) melt on smooth surfaces.*

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